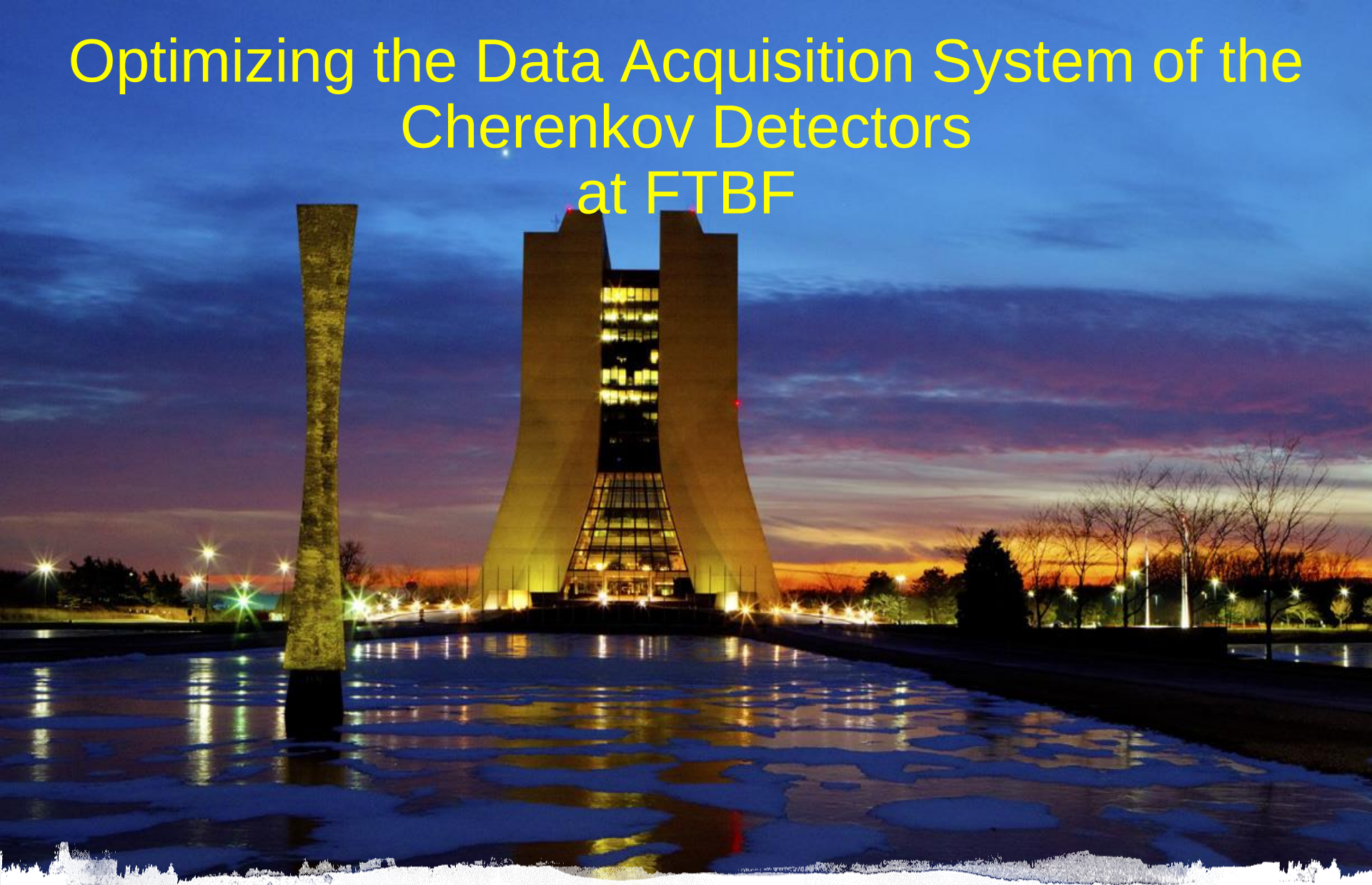
Optimizing the Data Acquisition System of the Cherenkov Detectors at FTBF



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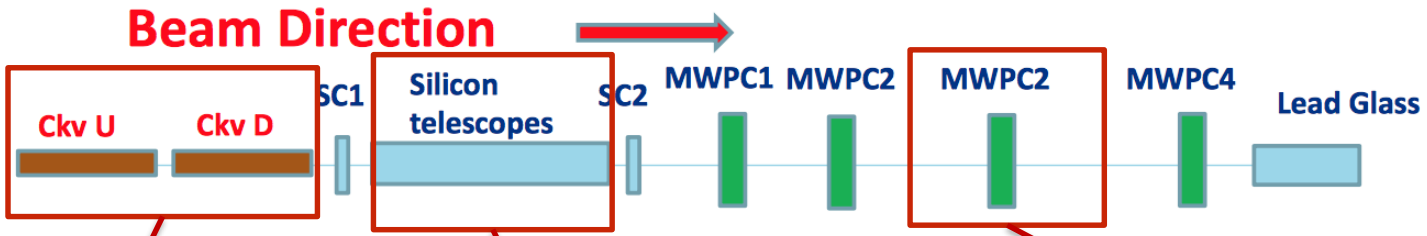
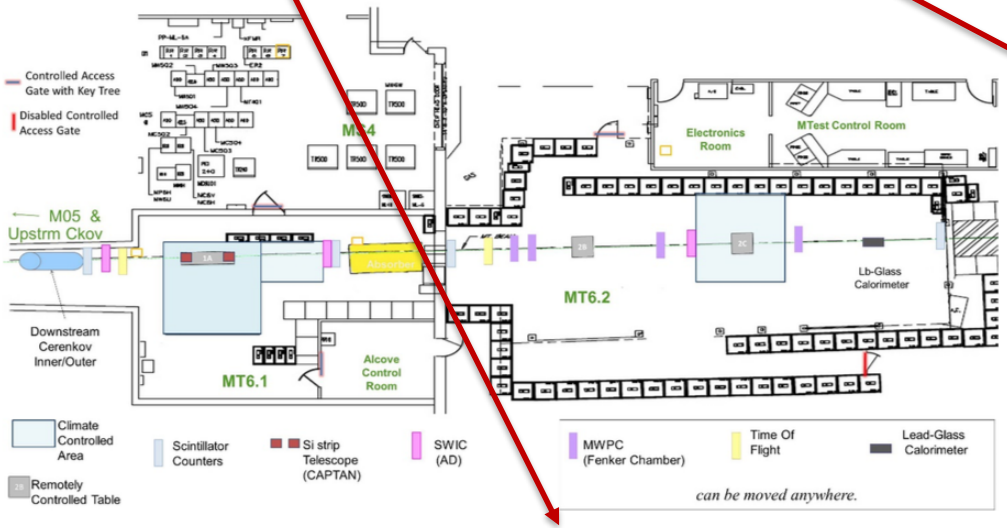
Fermilab Test Beam Facility (FTBF)

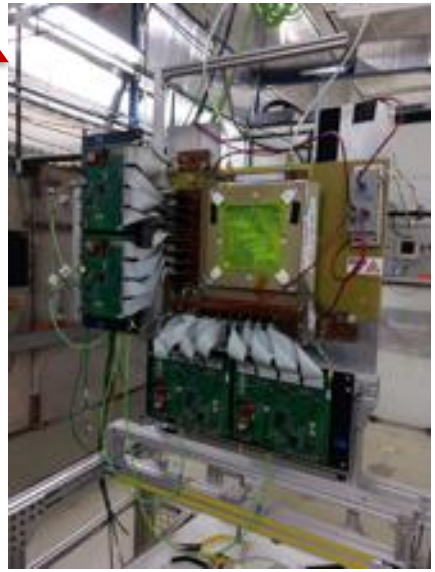
One of the two facilities in the world dedicated to detector R&D and other experimental work.

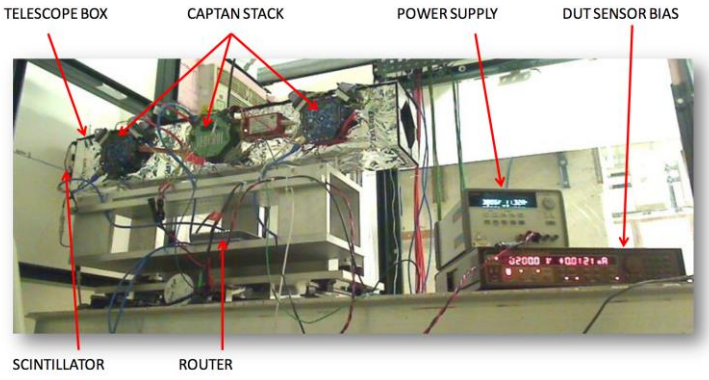
- In operation since 2005
  - Served about 1000 people from over 30 countries
  - Users include NOvA, CMS, LArIAt, g-2, etc.
- 2 Beamlines
  - MTest (2-80 GeV mixed, 120 GeV protons) - frequently used
  - MCenter (200 MeV – 2 GeV mixed)

Instrumentations Layout at MTest

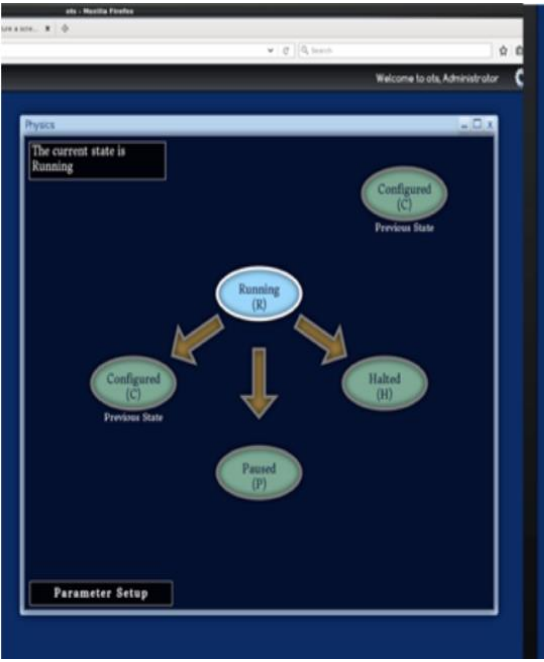


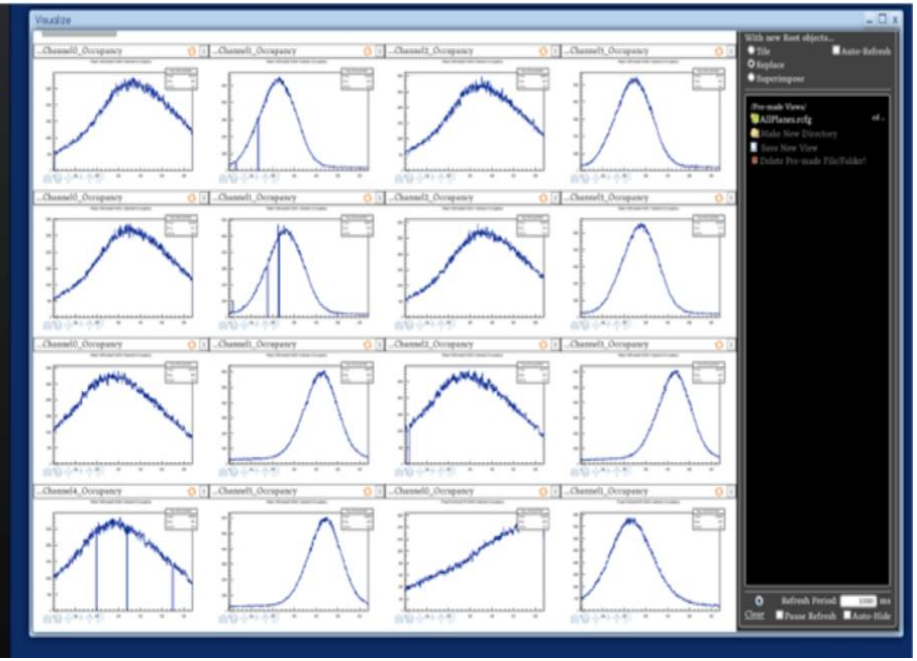






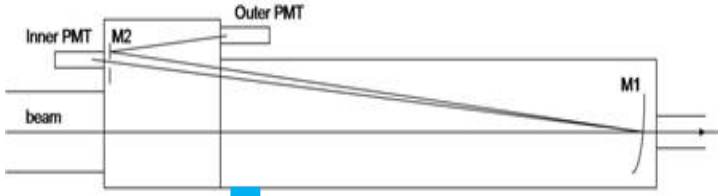
How do we read out data from detectors?



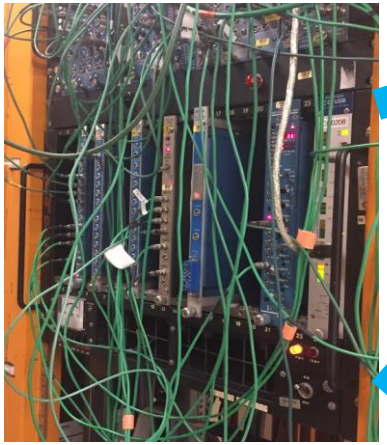


- otsDAQ is a software created by computer scientists at Fermilab to aid reading out the beamline instrumentation in support of FTBF users
- Ability to generate real-time useful plots of each 4-seconds beam spill which is viewable on a web-based GUI
- Read out system of the Cherenkov detectors is not fully implemented on otsDAQ!

Problem & Task



PMTs

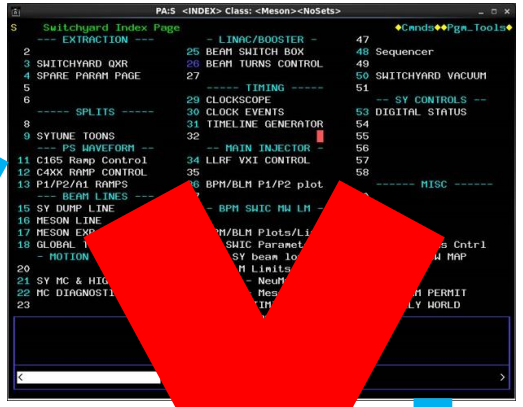


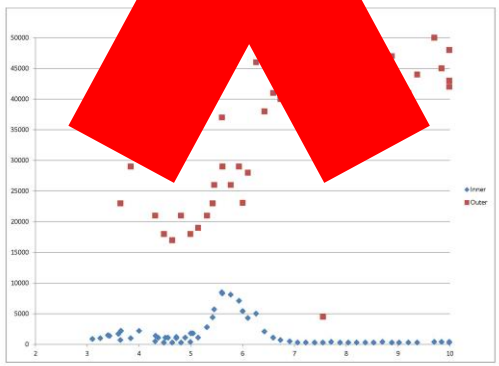
Electronic modules

My Task

otsDAQ

Histogram Plots

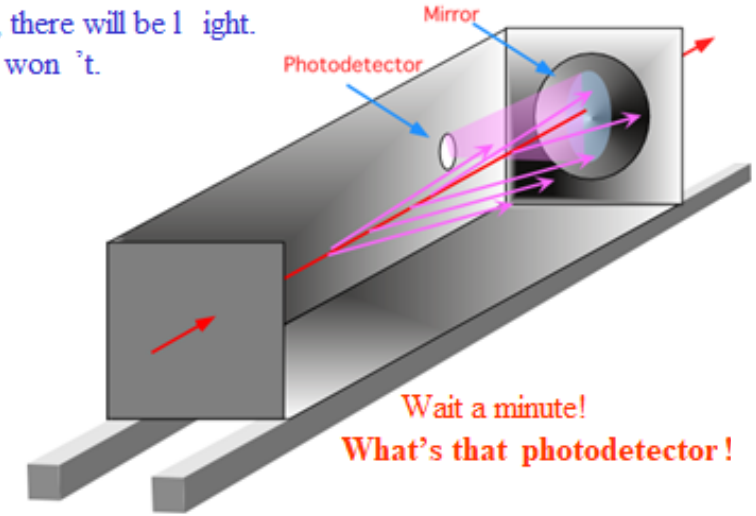


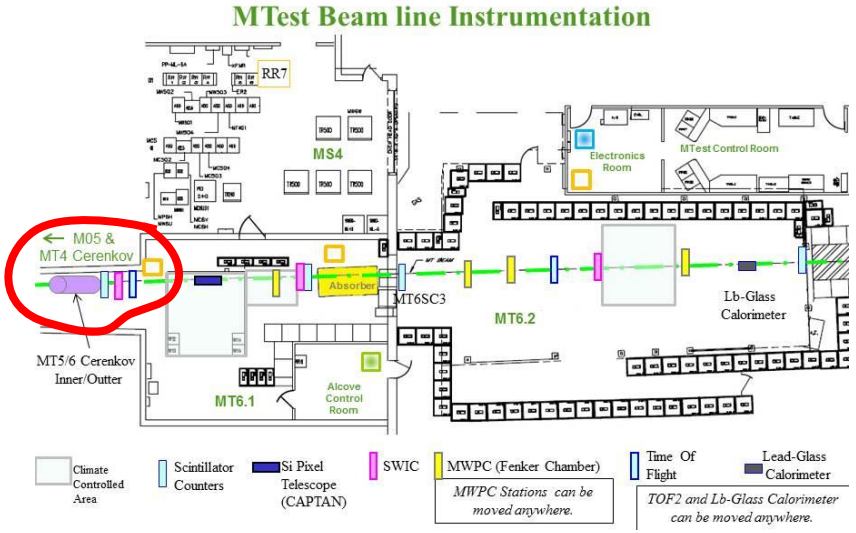


Cherenkov Detectors

- Cherenkov detectors are used for particle identification.
- They work on the basis of Cherenkov radiation.
- Two Cherenkov (Upstream and Downstream) at MTest section of FTBF.

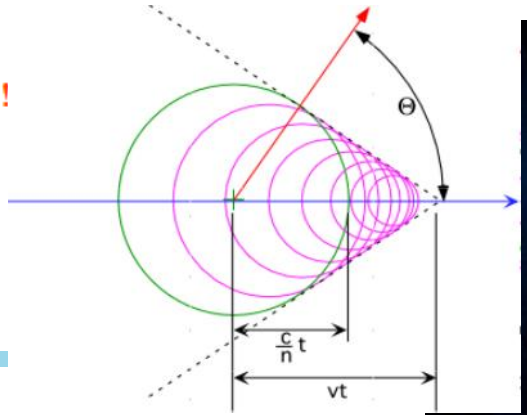
Particle Detectors…
Cerenkov Counter

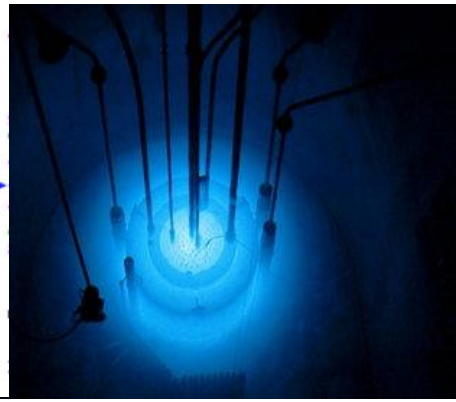




Cherenkov Effect:

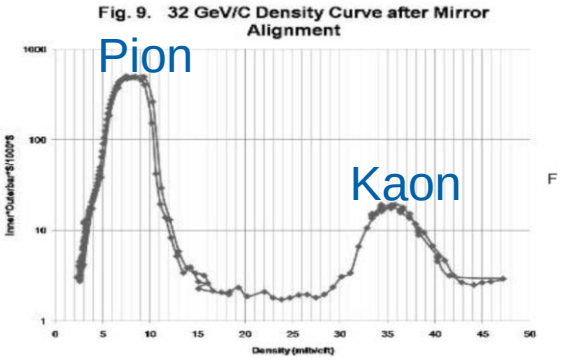
Turns ON when particle speed is greater than light speed in the medium: $v = \beta c > c/n$





Identification Methods

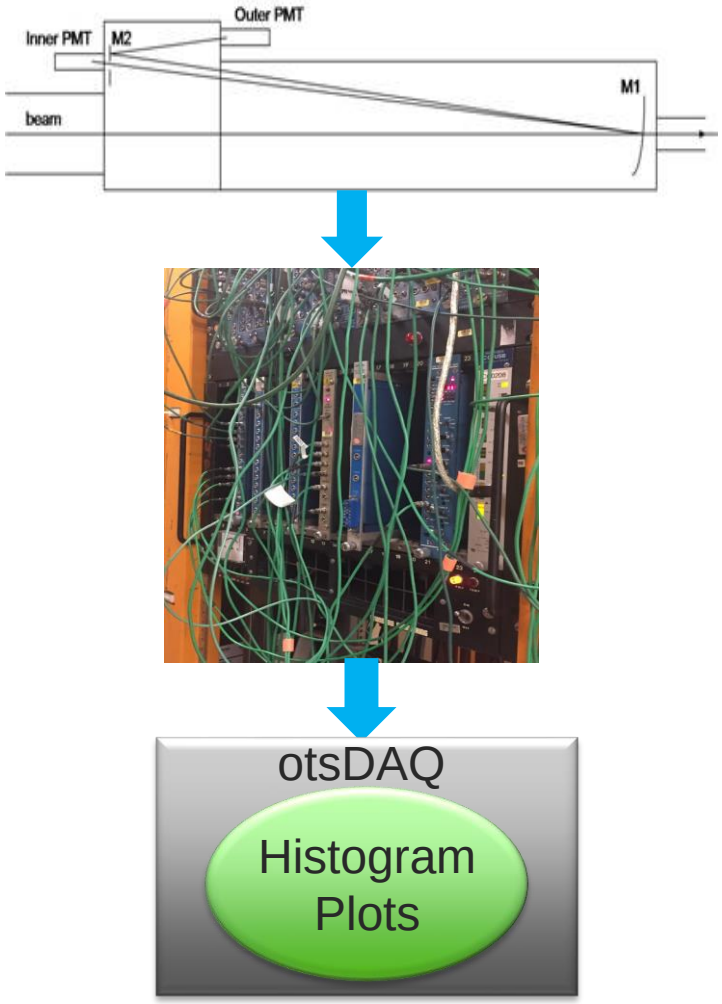
- The light produced is reflected/focused by a mirror and detected in Photo-Multiplier Tubes (PMTs).
- Once the angle of the light cone is known, the velocity of the particle can be found from the relation $\cos(\theta_c) = \frac{c}{nv}$
- Since the momentum is usually known, the mass of the particle, thus the particle, can be identified e.g muons, pions, kaons, protons & electrons
- The velocity of the particle is dependent on the refractive index which is a function of the pressure of the gas in the detector (Nitrogen).



Cherenkov Angle → Velocity → Mass → Type of Particle

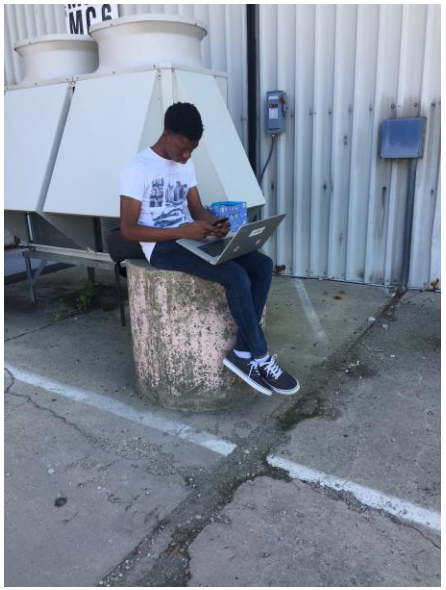
Important Plots

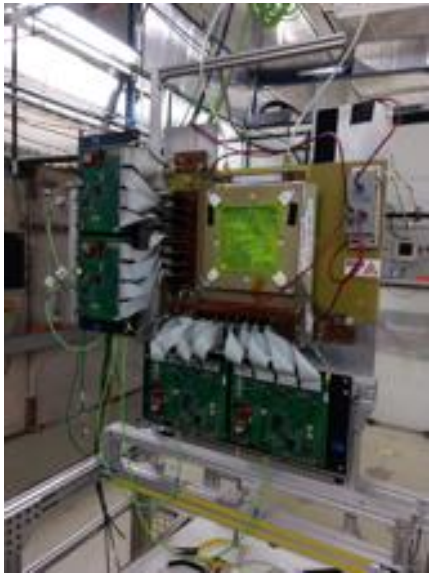
- For every 4-seconds beam spill, thousands of particles deposit some amount of photons detected by the 3 PMTs.
- PMTs convert photons to analog signal which is sent to electronic modules.
- ADC module – converts signal to digital and stores the photon counts.
- Scalar module – stores photon counts above some threshold to account for noise.
- Number of Particles vs ADC Counts
- Pressure vs Scalar Counts



How did I do it?

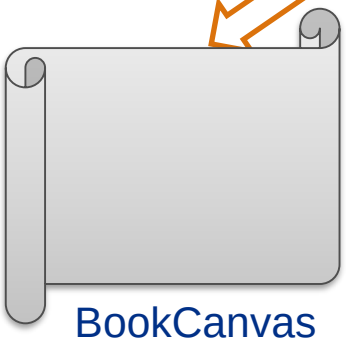
- Learnt some C++, Linux, and Root 😖
- Obtained similar program for the MWPCs at FTBF
- Following the structure of the program and using artdaq methods, developed the program for Cherenkov
- Tested program on different datafiles





Program Overview

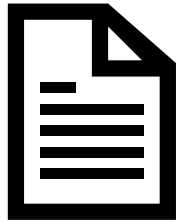
Analyze



BookCanvas
Creates a canvas that can be sketched on

BookHistos
Defines the bins, titles & axes for the histogram

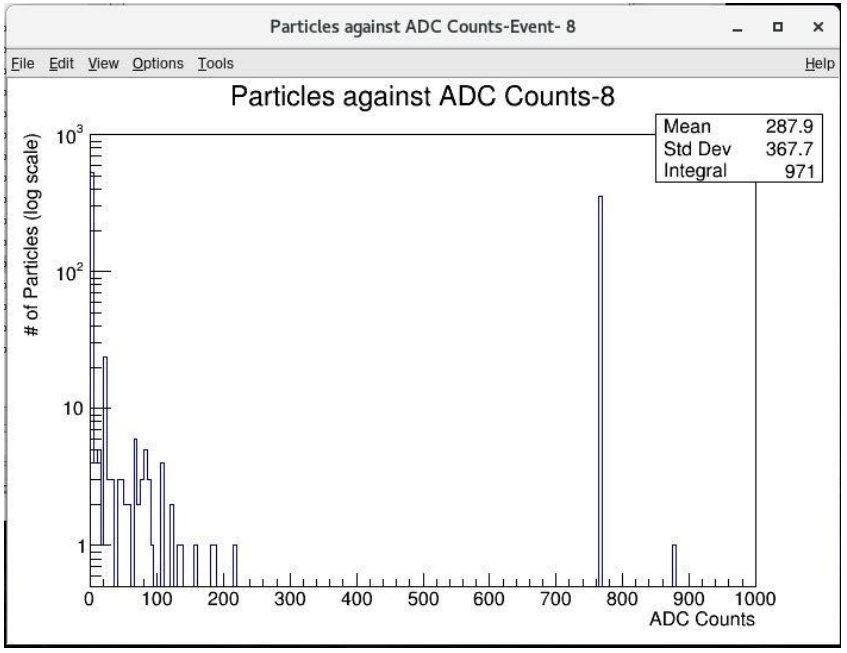
Fill
Extracts the useful data, fills the bin, and draws on the canvas

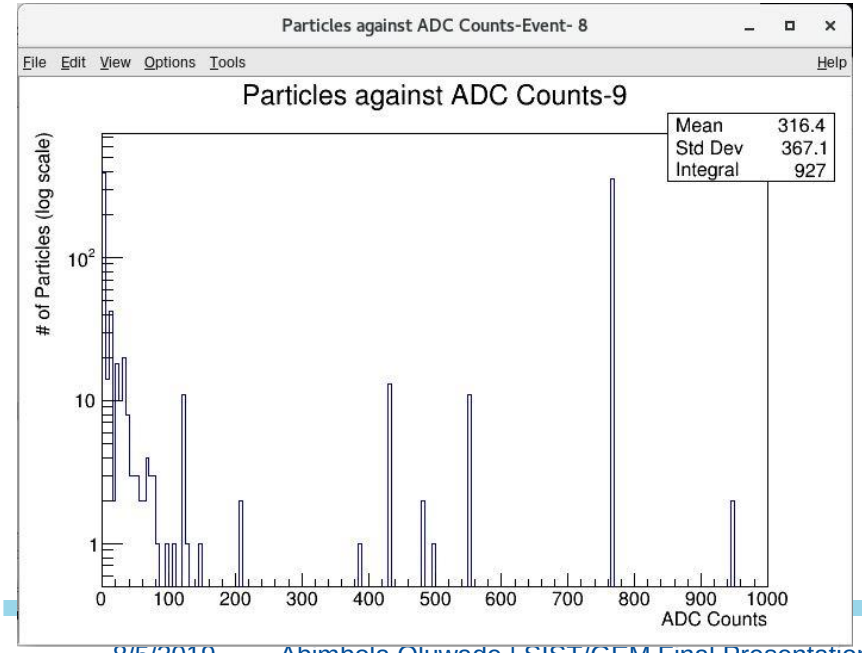


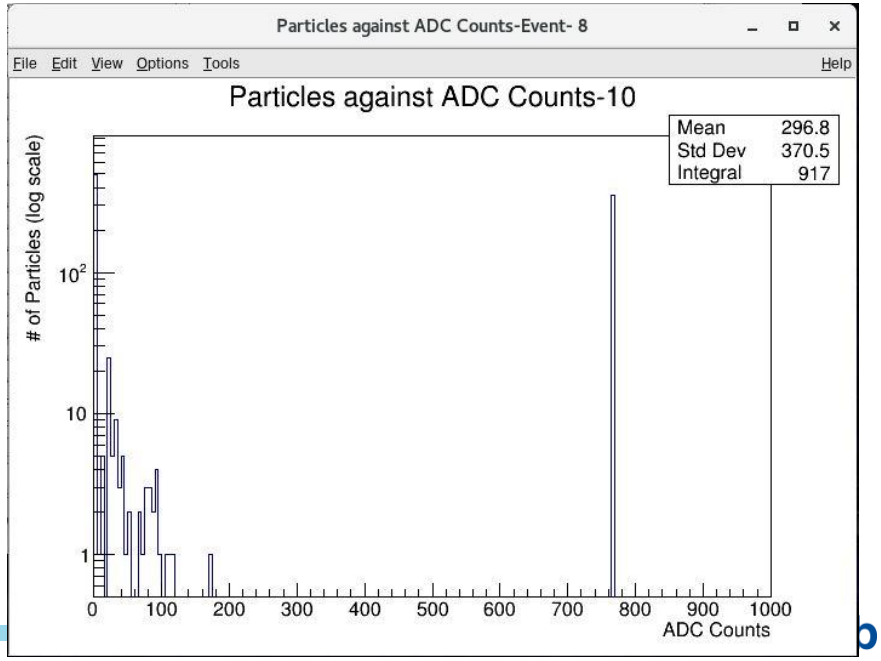
Write
Creates directory in Root and stores the plot for each event

Result

- Program is capable of making plots for the ADC counts.
- Histograms of a beamspill with 1000 triggers are shown







Future Work

- Complete Pressure vs Scalar Counts histogram.
- Debug for the sake of efficiency.
- Test the program during live beamspill when accelerator is back on.

Summary

- FTBF is a world class facility for detector R&D
- It contains different detectors along the beamlines for the benefit of users
- otsDAQ is the software used for reading out data form detectors at FTBF
- Cherenkov detectors' read out system not fully embedded in otsDAQ
- Cherenkov detectors are used for particle identification
- Tasked with 2 important histogram plots
- Steep learning curve but gotpart of it done
- Program capable of making histograms for ADC counts
- Further work will focus on expanding the program for other important plots.

Thank you ! 

Questions?